Robotic-Assisted Percutaneous Coronary Intervention Through Transradial Approach:

Experience in 4 Patients with Complex Lesions

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*Robotic-assisted percutaneous coronary intervention can reduce the exposure of interventional cardiologists to radiation and minimize the risk of occupational orthopedic injuries from wearing heavy protective aprons. The PRECISE (Percutaneous Robotically-Enhanced Coronary Intervention) study showed the efficacy and safety of robotic-assisted procedures for relatively low-risk lesions in single coronary arteries. Several reports have described robotic-assisted treatment of complex high-risk lesions, mostly through the transfemoral approach. We report 4 cases of patients in whom we used the transradial approach to treat complex lesions in the left anterior descending coronary artery with bifurcation balloon angioplasty reconstruction (2 cases), in the ostium of the first diagonal branch, and in the right coronary artery. **(Tex Heart Inst J 2020;47(2):144-8)**

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Advances in coronary revascularization have improved outcomes and made percutaneous coronary intervention (PCI) the most common method of revascularization. Complex and multiple-vessel PCI is routinely performed in most centers. However, the longer procedure times have raised concerns about the increased exposure of patients, interventional cardiologists, and catheterization laboratory staff to radiation and the possibility of occupational orthopedic injury from wearing heavy, radiation-shielding lead aprons during procedures.[1-3]

These concerns have led to the development of robotic systems for PCI. The CorPath® 200 (Corindus Vascular Robotics) was the first such system approved for use in humans. It has 2 major components: a robotic arm mounted onto the catheterization table and a radiation-free cockpit from where the interventional cardiologist remotely operates the equipment from a sitting position. The system enables controlled advancement of guidewires and stents and accurate measurement of lesion length, thus reducing the risk of geographic miss. The excellent clinical procedural success rate (97.6%) in the pivotal multicenter PRECISE (Percutaneous Robotically-Enhanced Coronary Intervention) study[1-3] led to United States Food and Drug Administration approval in 2012.

The robotic arm of the CorPath 200 carries a 3-track cassette that is connected to a guide catheter and onto which equipment is loaded. One track, operated remotely by joystick, carries a guidewire. Another track, also remotely operated by joystick, carries a balloon or a stent. The 3rd track is operated manually and can be used only for positioning a device. In the limited previous experience with this system, PCI was typically performed via the femoral artery, and complex procedures were avoided.[1]

We performed transradial robotic-assisted PCI in 4 patients with complex coronary lesions. Two cases involved the left anterior descending coronary artery (LAD) with bifurcation balloon angioplasty reconstruction; one involved the ostium of the first diagonal branch; and one involved the right coronary artery (RCA).

Case Reports

Patient 1

Right Coronary Artery with Severely Stenotic Lesions. An 85-year-old man presented with new-onset exertional pain in the jaw and progressively worsening dyspnea on

exertion. His medical history included PCI, diabetes mellitus, peripheral vascular disease, and ischemic cardiomyopathy with a left ventricular ejection fraction of 0.35. Results of physical examination were unremarkable. A stress test with nuclear perfusion imaging revealed a large, severe, and partially reversible perfusion defect involving the inferoapical region. Coronary angiograms obtained through the right radial artery revealed severe stenosis of the RCA (Fig. 1A), and the decision was made to perform PCI. The robotic arm was then brought into the field. A 6F guide catheter was inserted into the right radial artery and advanced to engage the RCA. A balance middleweight (BMW) guidewire (Abbott Vascular) and a balloon catheter were each loaded onto one of the remotely operated tracks of the cassette. To support the guidewire and balloon catheter, a GuideLiner® catheter (Vascular Solutions, Inc.) was inserted onto the manually operated track of the cassette and advanced until its tip was positioned in the proximal RCA. The guidewire was then advanced across the lesion without difficulty, followed by predilation
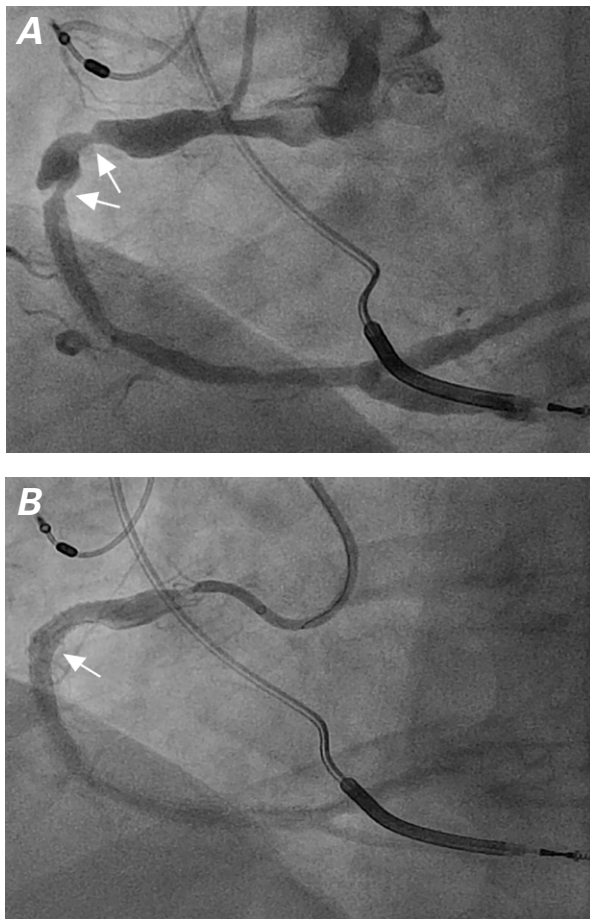

Fig. 1 *Patient 1. Coronary angiograms (left anterior oblique views) show **A**) severely stenotic complex lesions of the proximal right coronary artery (arrows), and **B**) restored flow through the drug-eluting stent (arrow) after transradial robotic-assisted percutaneous coronary intervention.*

balloon angioplasty and implantation of a 4 × 23-mm drug-eluting stent (DES) (Fig. 1B). The patient tolerated the procedure well and had no complications. The total procedure time was 65 min, and the fluoroscopy time was 15.1 min.

Patient 2

Lesion at Left Anterior Descending Coronary Artery and 2nd Diagonal Branch. A 78-year-old man presented with exertional angina and dyspnea. His medical history included anterior ST-segment-elevation myocardial infarction (STEMI) one month after initial PCI in the proximal LAD. Coronary angiograms obtained through the right radial artery revealed 80% stenosis of the mid LAD with involvement of the 2nd diagonal branch bifurcation (Fig. 2A), and the decision was made to perform PCI. The robotic arm was then brought into the field. A 6F extra backup 3.5 guide catheter was inserted into the right radial artery, then advanced to the left main coronary artery. A BMW guidewire and a 2.25 × 12-mm DES catheter were each loaded onto one of the remotely operated tracks. A second BMW wire was manually advanced distal to the 2nd diagonal branch. With robotic assistance, the first BMW wire was advanced past the lesion, and the stent was positioned over it. After stent expansion, the stent catheter was retrieved into the guide catheter and removed. Next, the diagonal branch wire was pulled back, proximal to the deployed stent, and then remanipulated through the stent struts into the 2nd diagonal branch. A balloon was advanced over the wire, after which the ostial diagonal branch lesion was dilated to achieve a satisfactory result (Fig. 2B). The patient tolerated the procedure well and had no complications. The total procedure time was 51 min, and the fluoroscopy time was 19.3 min.

Patient 3

Ostial Stenosis of First Diagonal Branch. A 53-year-old woman presented with exertional angina from activities of daily living. Three months before, she had undergone PCI to place a DES in a mid-LAD lesion. At that time, severe ostial stenosis at the first diagonal branch caused by stent placement ("stent jail") was noted but was left for medical management. Now, at the current presentation, coronary angiograms showed a patent LAD stent and 95% ostial stenosis of the first diagonal branch (Fig. 3A), and the decision was made to perform PCI. The robotic arm was then brought into the field. A 6F extra backup 3.5 guide catheter was inserted into the right radial artery and advanced to the left main coronary artery. A BMW wire was advanced into the guide catheter, positioned in the distal LAD, and then loaded onto the manually operated track of the cassette. A second BMW wire was advanced into the guide catheter, and a 2.75 × 12-mm DES catheter was loaded onto this wire. The wire and stent catheter were each loaded onto one

Fig. 2 *Patient 2. Coronary angiograms (left anterior oblique cranial views) show **A**) an 80% lesion at the bifurcation of the mid left anterior descending artery (arrow) and the 2nd diagonal branch (arrowhead), and **B**) restored flow through the bifurcation (arrow) after transradial robotic-assisted percutaneous coronary intervention.*
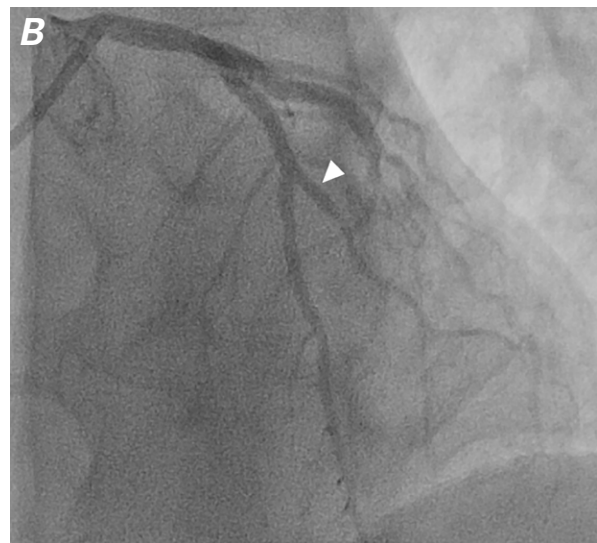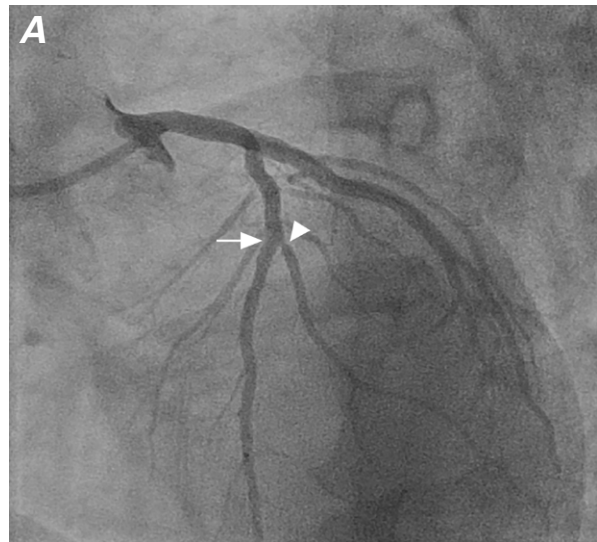

Fig. 3 *Patient 3. Coronary angiograms (left anterior oblique cranial views) show **A**) 95% ostial stenosis of the first diagonal branch (arrowhead) at its bifurcation with the left anterior descending coronary artery (LAD) (arrow), and **B**) restored flow through the first diagonal branch bifurcation (arrowhead) after transradial robotic-assisted percutaneous coronary intervention.*

of the remotely operated tracks of the cassette. With robotic assistance, the wire was successfully advanced into the first diagonal branch. Then the stent was advanced over the wire and deployed by using the T-stent technique (Fig. 3B). No procedural complication was noted. The total procedure time was 16 min, and the fluoroscopy time was 7.6 min.

Patient 4

Lesion at Left Anterior Descending Coronary Artery and First Diagonal Branch. A 63-year-old man presented with exertional dyspnea that had persisted for 2 weeks after he had undergone PCI for a mid-RCA stenosis. Coronary angiograms at the time had revealed 80%

stenosis at the bifurcation of the mid LAD and first diagonal branch (Fig. 4A). Given the patient's persistent exertional dyspnea, the decision was now made to treat the LAD lesion by PCI. In the catheterization laboratory, the robotic arm was brought into the field. A 6F Judkins left 3.5 guide catheter was inserted through the right radial artery and advanced to the LAD. A BMW wire was advanced manually into the guide catheter, positioned in the first distal diagonal branch, and then loaded onto the manually operated track of the cassette. A 2nd BMW wire was advanced into the guide catheter, and a 2.75 × 15-mm balloon was advanced over the wire. The wire and balloon catheter were each loaded onto one of the remotely operated tracks of the cassette.
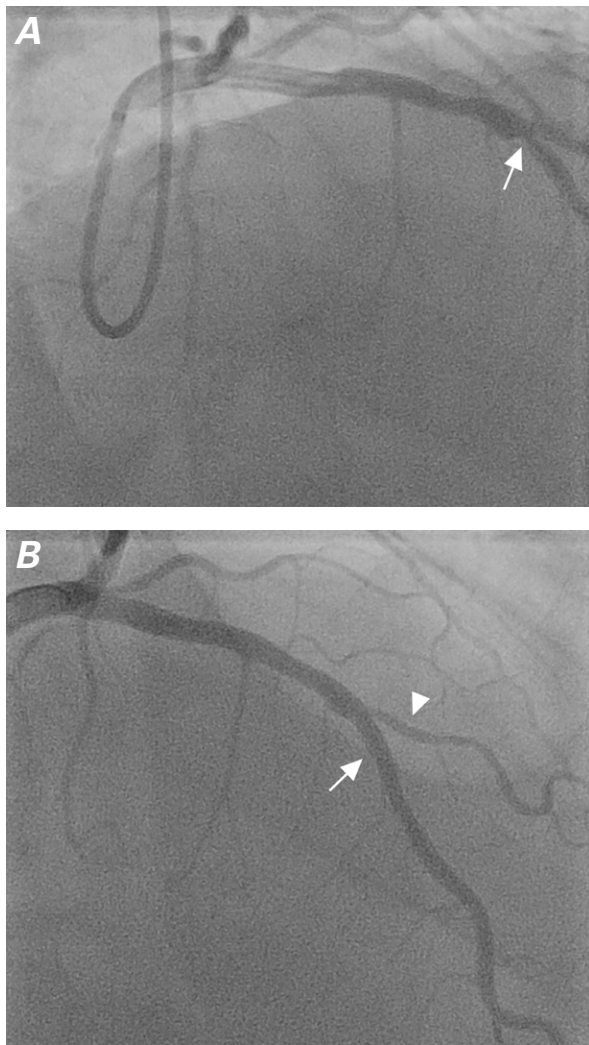
Discussion

Robotic-assisted PCI has the potential to improve the accuracy of coronary device placement and decrease occupational radiation exposure and physical strain.[1] Success rates for such procedures are excellent (above 97%), as shown in the PRECISE study.[1] However, the experience with robotic-assisted PCI so far has involved mainly relatively low-risk lesions in patients with single coronary artery disease and has excluded complex and high-risk lesions. The PRECISE study's entry criteria were stringent. They excluded patients in whom PCI, coronary artery bypass grafting, or directional or rotational atherectomy was planned.[1] They also excluded those who had severe tortuosity or calcification, occlusion, ostial location, bifurcation involvement, or unprotected left main coronary artery; those who required intervention in more than one coronary artery; those who had undergone previous stenting within 5 mm of the target lesion; and those who had intraluminal thrombus.[1] In addition, the mean diameter stenosis at baseline in the PRECISE study was 64.1% ± 10.9%.[1] Therefore, the effectiveness of robotic-assisted PCI in patients with complex and high-risk lesions still needs to be elucidated.[2,3]

As the experience with robotic-assisted PCI has grown, some investigators have explored the feasibility of using it to treat complex lesions. Mahmud and colleagues[4] searched a registry database and identified 6 successful cases of robotic-assisted PCI for unprotected left main coronary artery stenosis, with or without percutaneous hemodynamic support. Another group[5] reported 4 successful cases of robotic-assisted PCI for treating multilesion single coronary artery disease, multivessel cardiac allograft vasculopathy, saphenous vein graft disease, and STEMI due to proximal RCA occlusion. In all but one of the 10 cases, PCI was performed transfemorally.

Our 4 cases demonstrate the feasibility of performing robotic-assisted PCI on complex bifurcation and ostial lesions from the transradial approach. Further system improvements to these and other complex procedures, such as the ability of the 2nd-generation CorPath GRX® (Corindus Vascular Robotics) to manipulate guide catheters robotically,[6] are already being evaluated clinically. As the technology evolves, so too should the ability to perform more complex PCI procedures with robotic assistance, including through the transradial approach.

References

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Fig. 4 *Patient 4. Coronary angiograms (right anterior oblique cranial views) show **A**) 80% stenosis at the bifurcation of the mid left anterior descending coronary artery (LAD) and the first diagonal branch (arrow), and **B**) restored flow through the mid LAD (arrow) and first diagonal branch (arrowhead) after transradial robotic-assisted percutaneous coronary intervention.*

The LAD lesion was then predilated, and a 3 × 23-mm DES was successfully deployed. Next, the LAD wire was moved from its remotely operated track onto the manually operated track, and the wire previously positioned in the first distal diagonal branch was placed in the vacated remotely operated track. The first diagonal branch wire was then retracted into the guide catheter and readvanced into the diagonal vessel. Then a 2 × 15-mm balloon was advanced over the wire, positioned over the ostial diagonal region through the LAD stent struts, and dilated to achieve a satisfactory result (Fig. 4B). No procedural complication was noted. The total procedure time was 54 min, and the fluoroscopy time was 17.3 min.

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